Dental microwear and mechanisms in early hominids from Laetoli and Hadar.

During the 1980s the greatest discoveries in paleoanthropology relate the story of our origins in Africa where archaeologists have unearthed the species Australopithecus afarensis. revealed for the first time at Garusi and Laetoli (Tanzania). © photo Helga Roth

where the australopitecines left a series of footprints dating from 3.6 Ma, the most surprising locations are at the center of the depression Afar, along the Awash river (Ethiopia). There, the remains of hominids appear in a former swamp area, bordering a shallow lake, where there were a variety of mammals. They were in the region a wide variety of foods.

To understand the basic diet of the species, we must identify the sequence of morphological changes of the teeth and jaw in the evolutionary line. After collecting the information and recut it, it was found that significant changes concern particularly the anterior dentition and the maxillary canines became more symmetrical in profile and P_3 s less unicuspid. Dietary change is also suggested by the aspects of anterior tooth wear. It is the subject of the following paper that appeared in the American Journal of Physical Anthropology (1984)

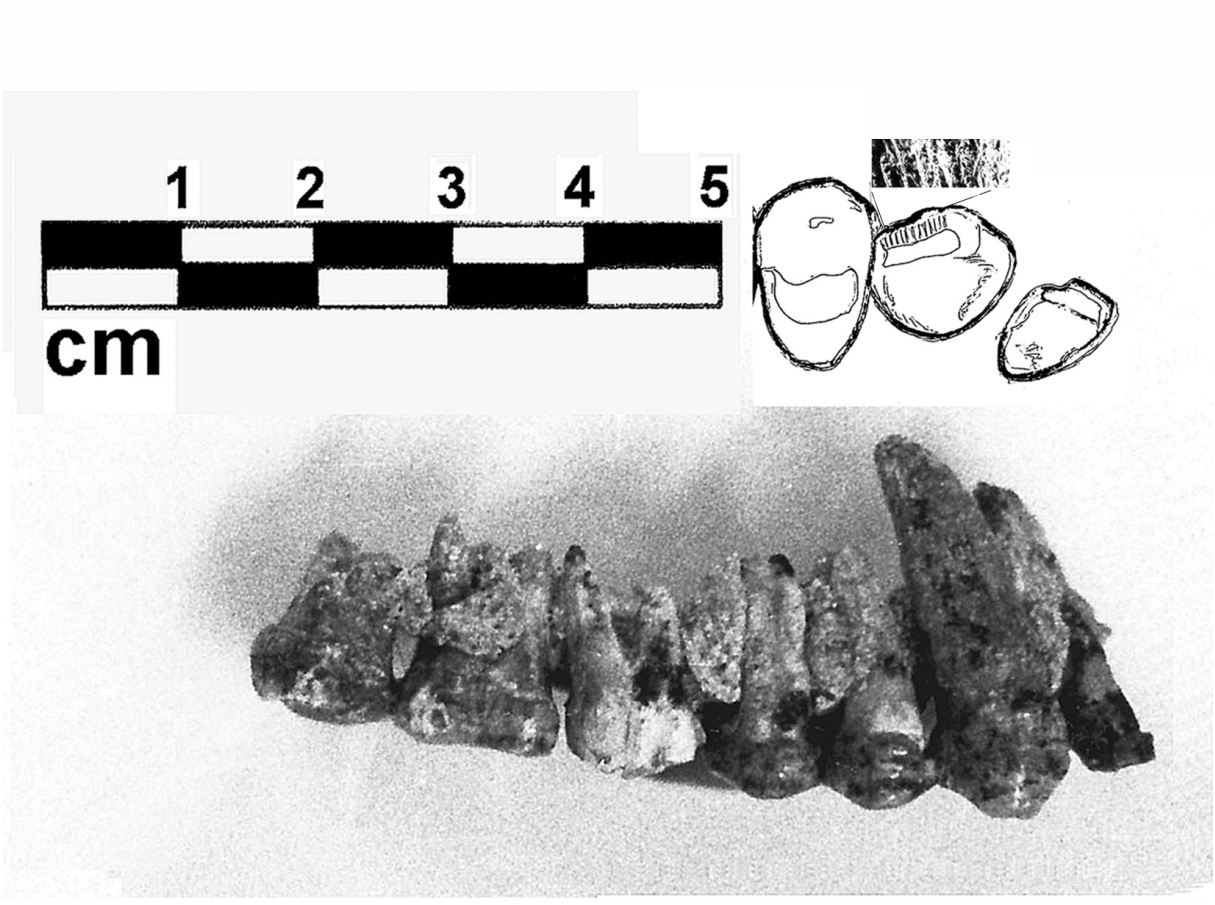
The dentition of early hominids from Laetoli and Hadar provide evidence of “incisal stripping” and a shear-grinding action for C/P_3 complex through microscopic examination of wear facets on upper canine/first lower premolar dental crowns. This masticatory pattern of dental wear resembles that of Papio papio and suggests behavioural analogies between early hominids and Papio.

The habitat of this reddish brown baboon species includes gallery forest, deciduous woodland and bamboo (42%), with the remainder of the land covered by non-wood vegetation. These non-wooded areas vary seasonally, sometimes having very tall grasses, and

at other times of the year being burned to the ground, creating very bare, open habitat. Papio papio has large canine teeth, especially in males, and the first lower premolar P_3 has been modified to serve as a hone for the upper canine. Baboons are omnivorous primates, subsisting often on roots, tubers, bulbs and corms of grasses. They will eat meat when it is available. (Dunbar, R., M. Nathan. 1972. *Social organization of the Guinea baboon, Papio papio*. Folia Primatologica, 17: 321-334).

For the anterior teeth, qualitative studies have suggested that Australopithecus afarensis has used its canines a great deal in preparing food showing quantity of scratches on the lingual surface of the upper canine, and those scratches running in a linguobuccal direction reflecting a tendency to pull out foods (leaf tissues of some plant species, especially grasses) between the front teeth. For the anterior teeth, qualitative studies have suggested that Australopithecus afarensis has used its canines a great deal in preparing food showing quantity of scratches on the lingual surface of the upper canine, and those scratches running in a linguobuccal direction reflecting a tendency to pull out foods (leaf tissues of some plant species, especially grasses) between the front teeth.

Analyses of canine micro wear have also yielded an interesting insight that may have be more generally applicable – i.e., that tooth-to-tooth contact in grinding teeth during some contexts to emit audibly sounds, produce crenulations reflecting dental microstructure as evidenced in the figure of Laetolil Hominid 5 with a micrograph of the disto-occlusal wear facet on the canine showing regularly spaced parallel crenulations



Audible teeth grinding is heard in *Papio* when two males are threatening each other at a close distance. One other possible function is that the C/P_3 grindings are designed to advertize to predators the number of adult male baboons present in a site, indicating the strength of the male defense.

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MINISTRY OF CULTURE AND SPORTS

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July 26, 1980

Monsieur Maurice Taieb
Laboratoire De Geologie De Quaternaire
Faculti des Sciences de Luminy - Case 907
13288 Marseille Cedex 2 - France

Dear Monsieur Taieb:

Please refer to your note dated March 21, 1980 regarding application made for Dr.P.F. Peuch inorder to make research concerning the hominid teeth of Afar.

Following your suggestion, we are pleased to inform you that Dr. Peuch could come to Addis Abeba to continue studies about the teeth of the Australopitheci Afarenses.

Sincerely Yours

Seyoum Wolde
Head, Intrnational Cultural Relations

AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 65:87–91 (1984)

Dental Microwear and Mechanisms in Early Hominids From Laetoli and Hadar

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KEY WORDS Dental wear, Laetoli, Hadar

ABSTRACT The dentition of early hominids from Laetoli and Hadar provide evidence of "incisal stripping" and a shear-grinding action for *C*/P3 complex through microscopic examination of wear facets on dental crowns. This masticatory pattern of dental wear resembles that of *Papio papio* and suggests behavioral analogies between early hominids and *Papio*.

The occlusal relationships and functions of the maxillary canine and mandibular third premolar (*C*/P3 complex) in early hominids from Laetoli have been described by Leakey et al. (1976), White (1981a, b), and Wolpoff (1979, 1981). The present study offers an adaptive interpretation of microscopic surface damage observed on the occlusal wear facets of the *C*/P3 complex of hominids L.H. 5 from Laetoli and A.L. 199 and A.L. 200 Ia from Hadar, through comparison with dental microwear seen in living *Papio papio*, whose diet and feeding behavior is known.

Upper canines in early hominids, L.H. 5, A.L. 199, and A.L. 200 1a, show asymmetric occlusal wear with a lower canine contact facet on the mesial occlusal edge and a third lower premolar contact, producing a longer distal wear facet with dentine exposure. Numerous microscopic striations caused by abrasion cover the lingual surface. The upper canine has two possible contact surfaces with P3. The smaller one, or apex, has rounded and polished edges covered by micropits and microflakes caused by puncture-crushing action on food. The distal wear facet is curved or flat. This pattern arises from damage producing regularly spaced parallel crenulations, 0.2 mm apart, slightly undulated across a part of the facet (Figs. 1, 2). These ridges on polished surface have been attributed to the elastic resiliency of foods causing frictional wear by a stick-slip mechanism (Puech and Albertini, 1983). This pattern is associated with changes in enamel prism direction called "Hunter-Schreger bands." The degree to which a prism is worn during polishing or acid-etching is determined by the angle at which its axis is directed towards the external surface. The occurrence of such patterns is related to physico-chemical properties of the diet of early hominids from Laetoli and Hadar. Prisms perpendicular to the surface are worn down less rapidly by polishing action than those parallel to the surface. This results from high pressure and friction rather than acid action, which would have first etched the prisms perpendicular to the surface and created a honeycomb appearance.

Similar crenulations are also present on premolars, molars and incisors of the material studied, but on rounded occlusal surfaces. For example, the upper incisors of A.L. 200 1a display an edge-to-edge bite and the distal occlusal wear facet on I^1 is crenulated. This microwear pattern would be expected to result from similar tooth activity.

Such crenulations can also be seen in other primates. In *Papio papio* "premolar chopping" of tough food substances that are carried to the side of the mouth involves increased masticatory effort and quick vertical strokes (Zanowiak, 1974). The microscopic examination of the wear facets on upper P3 of *Papio papio* (Fig 3) reveals the same pattern seen in the distal occlusal wear facet of the upper canine of early hominids from Laetoli (L.H. 5) and Hadar (A.L. 199 and A.L. 200 1a). In this form of chewing, food is crushed and the "bite" is transferred to a canine capable of withstanding a great occlusal load. The resultant wear surface can be divided into three parts as follows: 1) The

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Fig. 1. Early hominid from Hadar: A.L. 200 1a. Lateral view of cast of the upper jaw illustrating the disto-occlusal wear of the canine.

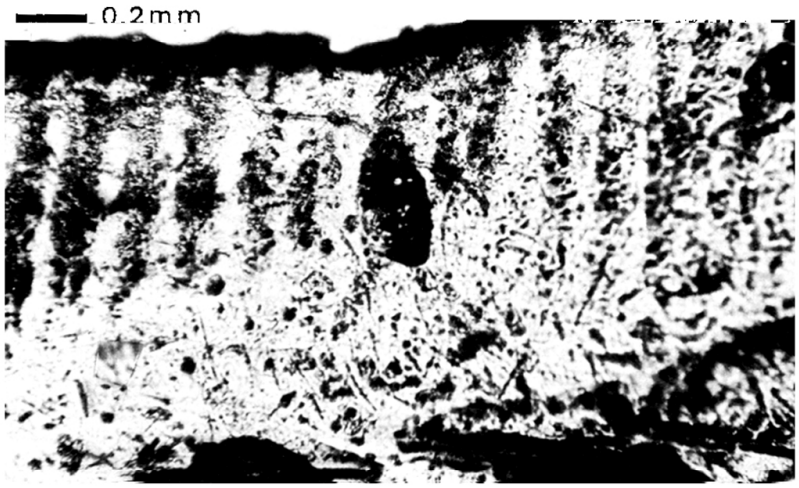

Fig. 2. A.L. 200 1a: micrograph of the disto-occlusal wear facet on upper right canine showing regularly spaced parallel crenulations.

first is formed of bucco-lingually-directed crenulations with some striations giving evidence of contact with food disto-mesially compressed by teeth coming into close contact; 2) The middle part with a curved surface and exposed dentine; 3) The last, located on the lingual side, exhibiting food abrasion marks.

The upper incisors in primates are used for separating pieces of food either by a stripping action or by cutting against the lower incisors. Such "incisal stripping" in baboons produces the characteristic irregular incisal edge also observed in early hominids (Figs. 4, 5). Microscopy of *Papio papio*, as well as early

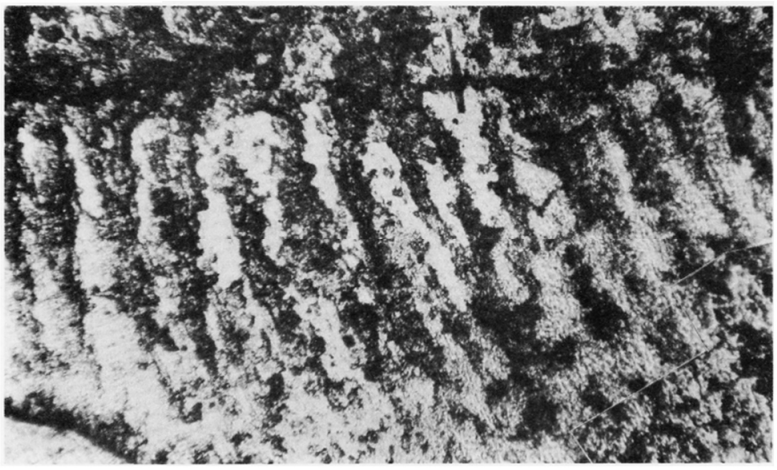

Fig. 3. *Papio papio*: detail of the occlusal wear on upper first premolar, showing crenulations.

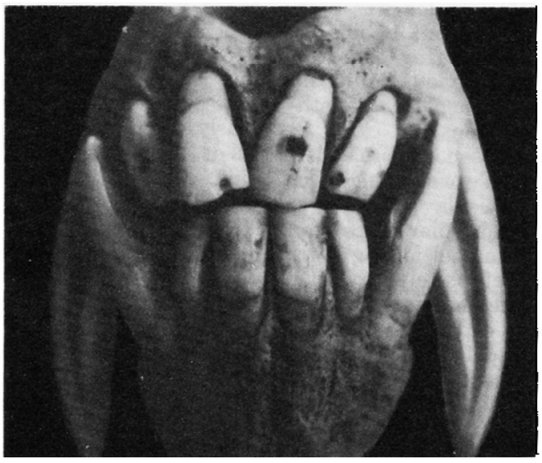

Fig. 4. *Papio papio*: anterior view with characteristic irregular incisal edge related to "incisal stripping and clumping."

hominid incisor occlusal surfaces reveals labiolingually oriented sets of fabriclike furrows related to incisal stripping but also the distinctive crenulation pattern to be related here with high pressure clamping. P4 and the molar teeth of *Papio papio* show striae made by abrasion due to "rotary chewing" motions of the mandible during mastication. The analagous macro- and microwear observed in early hominids from Laetoli and Hadar infers "incisal stripping," "canine chopping," and "molar rotary chewing." However, early hominids from Laetoli and Hadar also exhibit wear associated with processing of food on large crushing surfaces and short, blunt, rounded cutting edges.

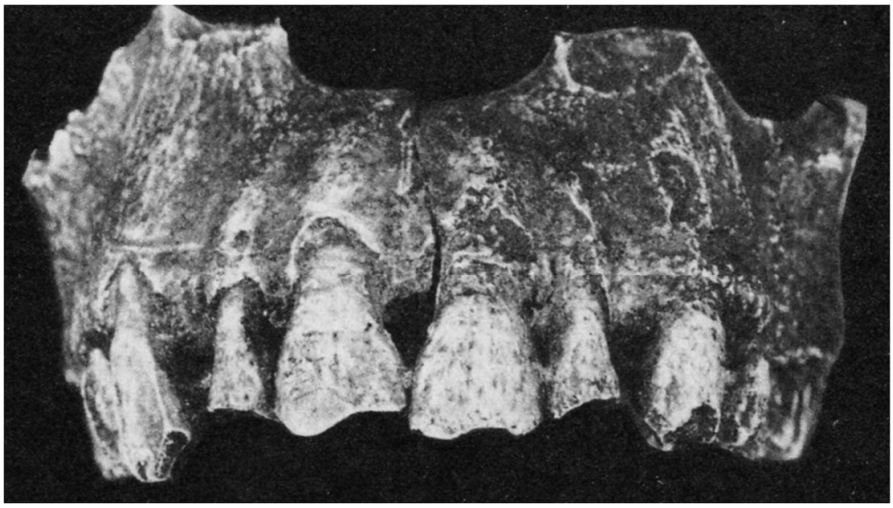

Fig. 5. Early hominid A.L. 200 Ia: anterior dental view of cast illustrating the typical wear of the upper incisors.

For the following reasons we suggest that the shear-grinding *C*/P3 complex was present early in hominid evolution: 1) blunted tips in older individuals indicating loss of the ability to shear in some individuals and the absence of this characteristic pattern in others indicate mixed functions for *C*/P3; 2) shortened canines, with absence of projection beyond the occlusal row in worn state of L.H. 5, improve grinding efficiency and lead to heavy wear of the P4 and molar cusps (one reason for thick molar enamel among hominids); 3) relatively and absolutely large but shortened canines reduce attrition on them and preserve puncturing capacity.

Humans are not the only primates that hunt and eat meat. Baboons and chimpanzees frequently kill and eat any other mammal small enough to capture and subdue (Morris and Goodall, 1977; McGrew et al., 1982). But *Papio papio* eat no more than two to five % meat, an amount insufficient to account for dental wear patterns. By analogy, we expect that factors other than meat-eating must also be sought to explain peculiar early hominid dental wear.

Early hominid dental adaptations such as cheek teeth with low surface relief and thick enamel indicate extremely powerful chewing forces. Comparison of the dental wear of a *Papio papio* with that of early hominids from Laetoli and Hadar suggests transfer of the shear-grinding action from P^3 to *C*, associated with incisal stripping and clamping. Baboons living in open savanna habitats are dependent on a diet of small, hard vegetable materials requiring considerable mastication and leading to heavy wear (Dunbar, 1976). Meat, for baboons, is obtained fortuitously and without regard to nutritional needs, but when it is available, bones, skin, hair, and teeth are all consumed (Teleki, 1973).

From the foregoing, we conclude that the dental microwear of early hominids indicates adaptation to a very powerful mastication. Meat-eating adaptations came later, over the last 1–2 million years, as hunting success increased and with developed tools.[1] Thus, anatomical features associated with powerful chewing forces served as a preadaptation for an increased emphasis on meat consumption.

ACKNOWLEDGMENTS

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[1] In Papio baboons, carnivorous behaviour is more frequent in arid habitats; it is therefore possible that ancestral hominids invaded the African savannas as accomplished hunters (Dunbar 1976).

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13/8/84

Dear Dr Puech,

Many thanks for your letter and reprints. I will endeavour to obtain the samples you require, but I now live near Nairobi and only visit Olduvai periodically.

I found your paper interesting but cannot understand how tooth wear can support the theory that H. habilis was arboreal. The pollen spectrum at Olduvai is well known and has been published by R. Bonnefille. It would be relevant to your study.

Yours Sincerely

M. D. Leakey.